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TITLE: HIGH-SPEED VIDEOGRAPHY FOR OPTICAL AND X-RAY IMAGING

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MASTER

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HIGH-SPEED VIDEOGRAPHY FOR OPTICAL AND X-RAY IMAGING

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HIGH-SPEED VIDEO SYSTEM

The SP-2000 Motion Analysis System, or high speed video (HSV) can record up to 2000 full frames per second or up to 12,000 partial (hex) frames per second with a playback speed of 60 frames per second, thus allowing a slow down factor of up to 200 times in the recorded action. The system is quite portable as well as being capable of supporting two cameras simultaneously. The two images, which could be views of the same event from different angles and/or different fields of view or depth of field, can be viewed on the same TV monitor by use of picture inset techniques with variable size and positioning of the inset. Other useful features of the high speed video system includes a data frame as seen in the above figure and X and Y reticles that can be activated on replayed images to give accurate position data for any desired frame. These reticle lines are illustrated in the upper frame of Figure 1 positioned on the center of a small sphere giving a horizontal (X) and vertical (Y) position with the X and Y position values indicated on the right side of the monitor (data frame). Also notice in the data frame, in a clockwise manner, from upper left, the time of day, date, elapsed time since the beginning of recording of the particular frame being viewed, identification number, X, Y, recording rate in frames per second, frame count, tape count as well as status messages such as "Stopped" and "Still Image."

The great appeal of the high speed video system is the live camera setup conditions which allow likely success on the initial recording and the immediate playback feature common to all video systems. Also, the fact that this data is in digital format means that with our optional computer interface, information such as the aforementioned X and Y data can be directly input to a computer.

These convenient features are the result of a number of technological advances. These include a solid state video sensor, specialized microgap recording heads, high density magnetic recording tape, microprocessors for a wide range of sophisticated controls that are nonetheless simple, small, and which are essentially immune to operator error.

Optical Applications

High-speed video can be used to document a wide range of dynamic events, ranging from small scale laboratory experiments to large field tests.

Laboratory type tests include observation of pressure tests to destruction of small diameter spheres to learn the failure mechanism, ignition and combustion of heat powder samples to determine burn-rate data and circulation of beads in various

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liquid media. The latter example is illustrated in Figures 1 and 2 where two frames, 0.37 second apart, and recorded at 1000 frames per second show the relative movement of various beads and allow determination of object velocity, acceleration, and spin rate. Other laboratory tests include diagnosis of laser welding, arcing of large electric motors and many types of high-velocity mechanical actions.

Among larger scale field tests using high-speed video is the observation of rocket-assisted drop tower experiments where the two cameras record a metal shearing process and projectile progress in order to determine acceleration data.

High Speed Video Combined with Dynamic Radiography

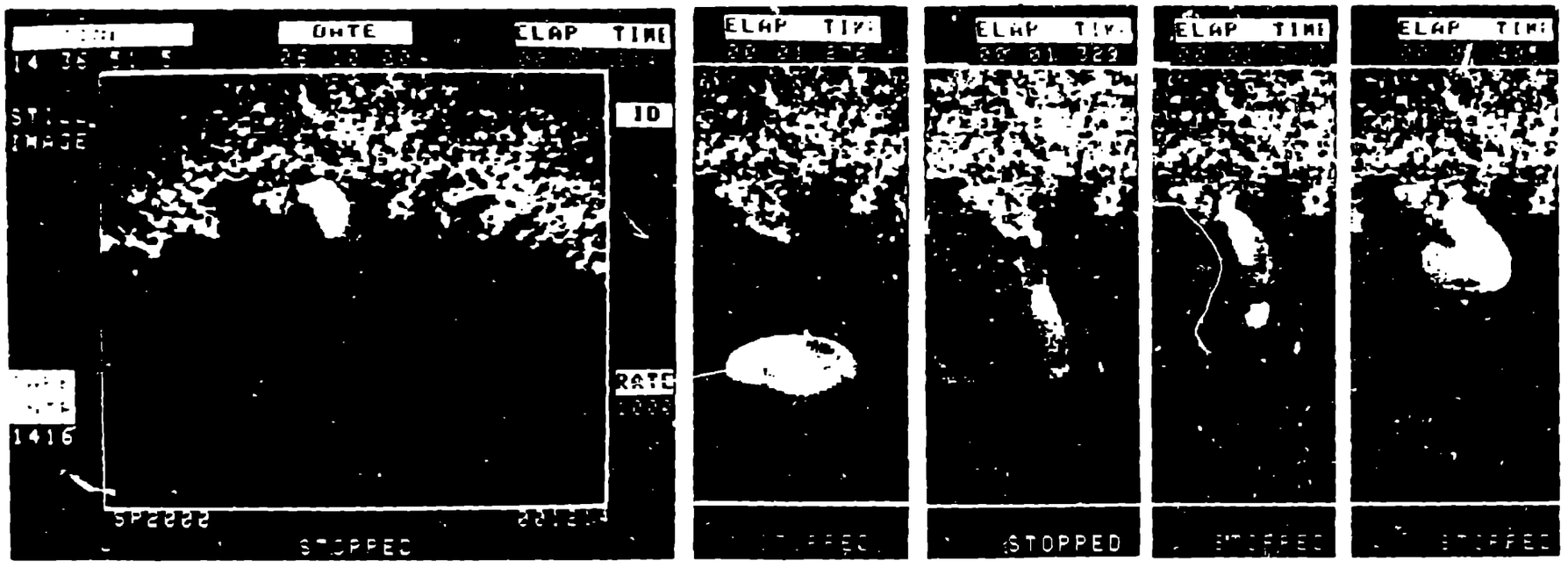
The system thus far has been described in terms of direct optical observation of high-speed events. However, the same camera can be used to monitor the output fluor of an x-ray sensitive image intensifier. When combined with an x-ray generator, the high-speed video/x-ray image intensifier allows recording of dynamic radiographic images up to the same maximum 12,000 partial frames per second.

The x-ray image intensifier consists of an input fluor which converts x-rays to light, a photoelectron layer which converts the light to electrons and an electron acceleration, or intensification stage and finally the electrons are converted back to light at the output fluor. Both the input and output fluors have decay constants of 650 nanoseconds or less which results in no motion blur when recording up to the maximum frame rate of the high-speed video system.

Applications of High-Speed Video/Dynamic Radiography

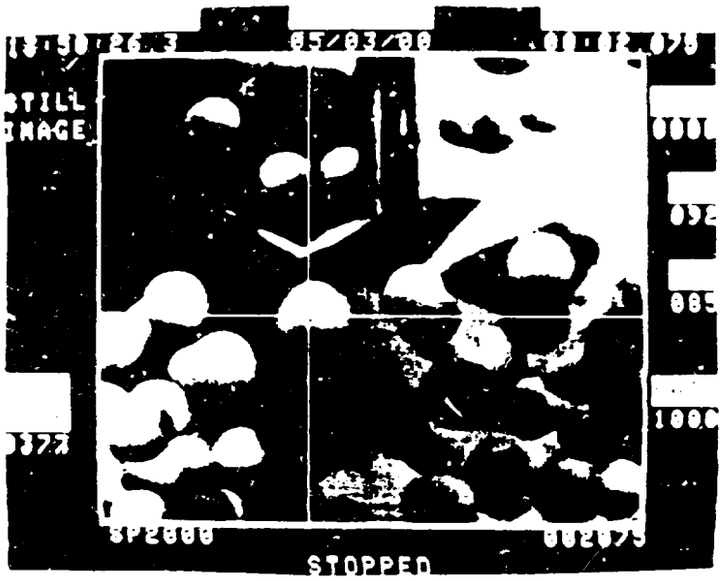
Dynamic radiographic imaging of the mechanical actions of a clock and a compressor have been demonstrated. A typical setup is seen in Fig. 3 (left to right): (A) x-ray tubehead, (B) object to be inspected (in this case, a cylinder), (C) x-ray image intensifier, and (D) high-speed video camera. In Fig. 4, two frames of a clock, 0.035 second apart, show an obvious change in the balance wheel rotation at the right center region of the frame.

Figure 5 illustrates combined optical and x-ray imaging where a fan operating at 1200 rpm is seen (optically) in the lower left corner. The remainder of the image is the x-ray visualization of a lead marker mounted on one blade of this fan. The frame rate is 4000 pictures per second with the upper and lower images separated by 1/4000 second. This illustration is of both the second image inset capability (optical image inset in x-ray image) and the split frame feature (two images separated by a small time interval and shown on the same video frame).



Sequence of high-speed video images of a water-filled balloon falling on pavement. The balloon flattens much like a pancake in the second image, rebounds into an almost vertical bottle shape in the third and fourth images, and resumes a nearly spherical configuration in the final image.

Used Photo - Not mentioned in text



Spheres circulating in liquid media; x-y motion activated

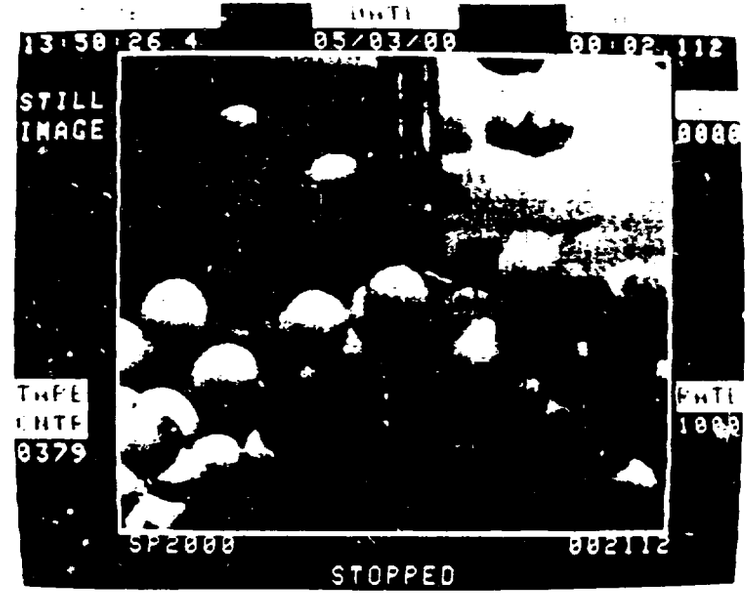
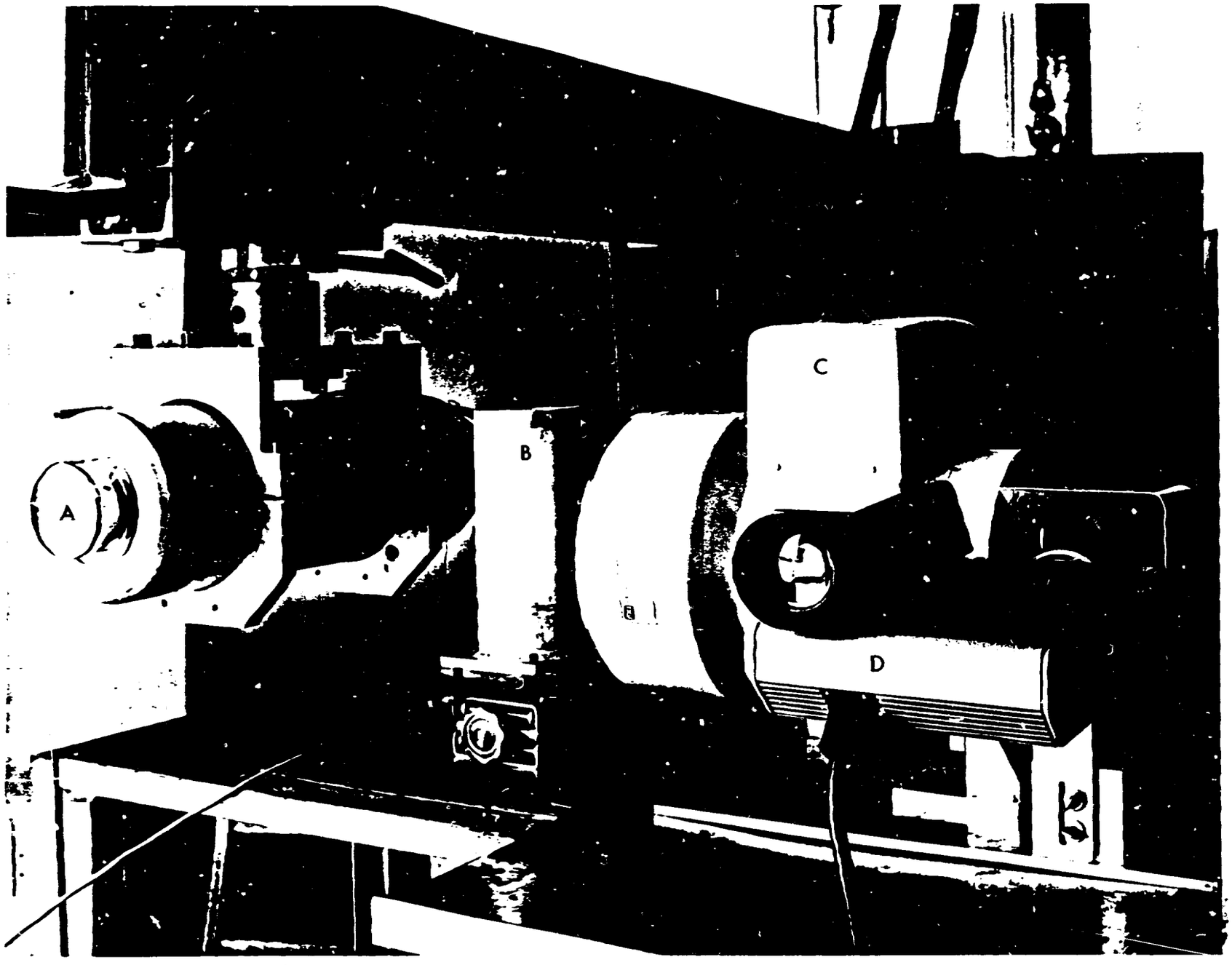
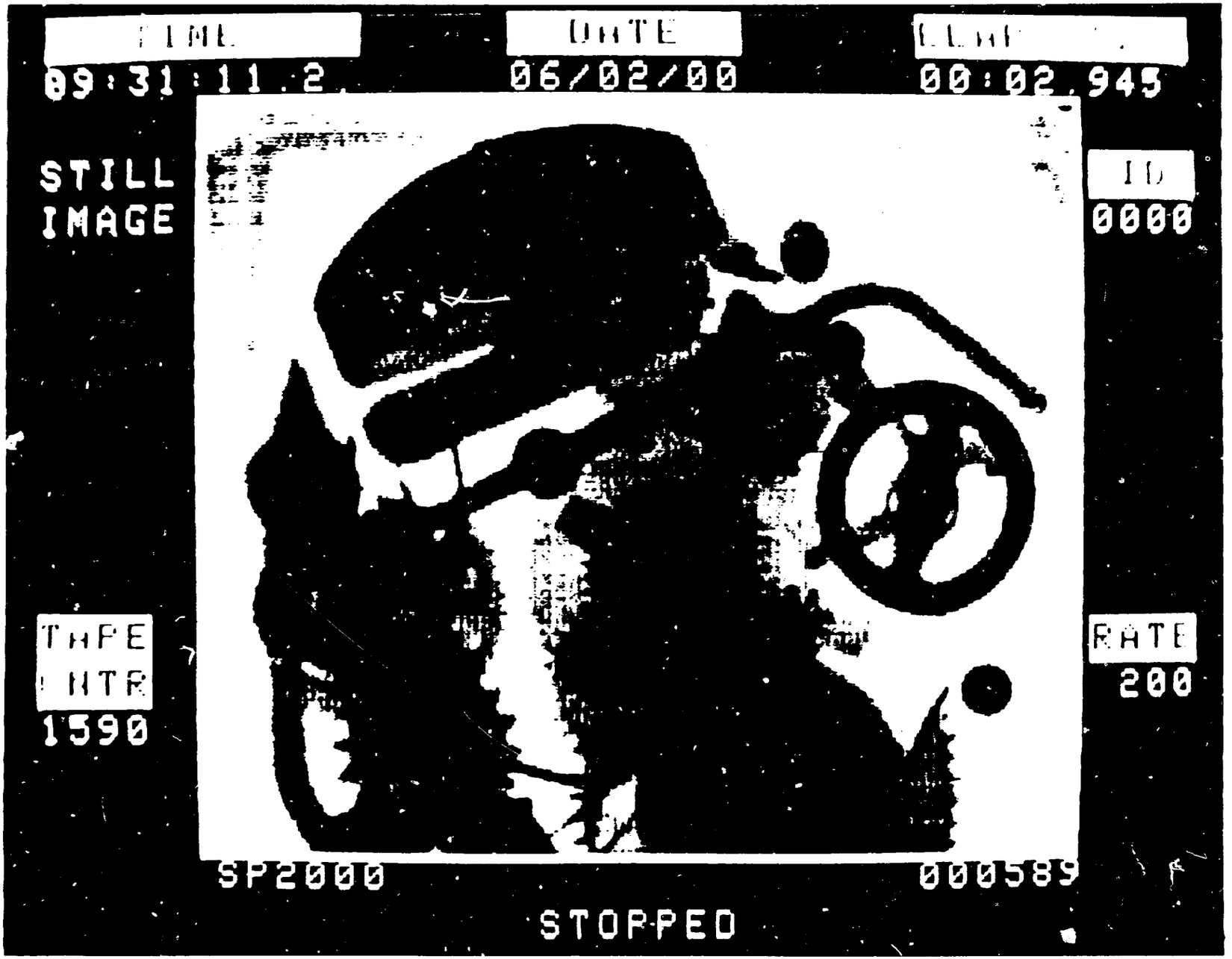


Image of sphere 0.3"s after Figure 1

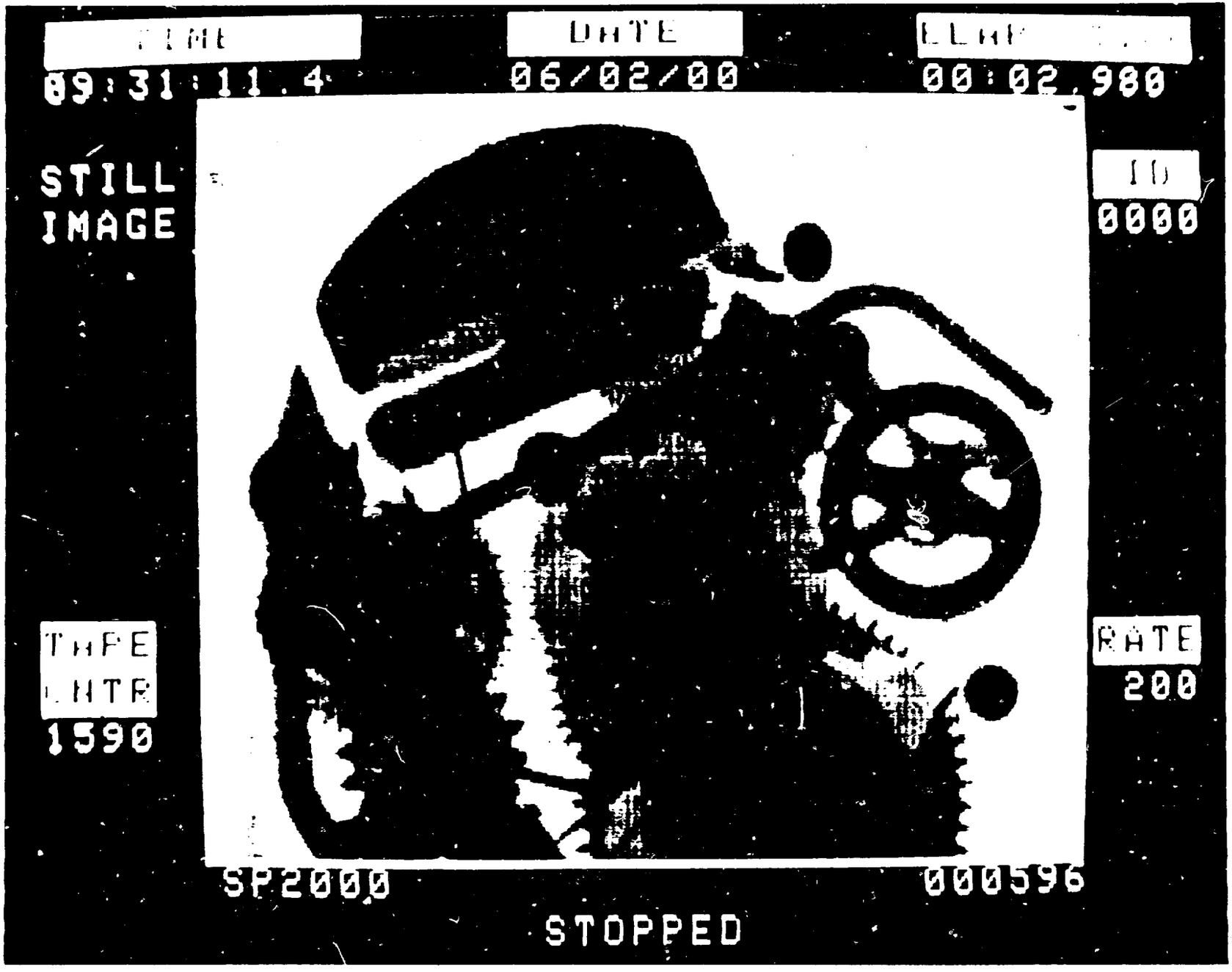


91 x-ray Tube Head (B) Object to be inspected (C) x-ray Image Intensifier (D) Cath[illegible]

Combined natural & x-ray [illegible]



High Speed Video/X-ray Image of Wiring Circuit Board at 200 frames per second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